Problems in Minimum Ignition Energy Determination

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This Seems Well Understood

Well, not really.

The determination of minimum ignition energy curves for fuel/air mixtures have been problematical with widely varying results for different groups using different fuels, fuel treatment regimes and ignition sources.

The focus of attention on the root cause of the variations has been in the fuel and fuel treatment. While there is considerable variation in refinery products and handling such variations are also observed for chemically pure fuels.

Perhaps there are other concerns.
Type of Ignition Source

- **Hot Wire**
- **Spark**
- **Optical**

<table>
<thead>
<tr>
<th>Type</th>
<th>Physical Chemistry</th>
<th>Chemical Engineering</th>
<th>Mechanical Engineering</th>
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<tbody>
<tr>
<td><strong>Duration</strong></td>
<td>ns</td>
<td>µs</td>
<td>ns</td>
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<tr>
<td><strong>Initiation</strong></td>
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Combustion Vessel
GRC MIE Experimentation
Combustion Vessel Apparatus
Sparks Move Around

30 μs later
“Dancing” Spark
30 μs Between Frames
GRC MIE Experimentation
Combustion Vessel Apparatus ~ Internal Configuration
Typical Ionization Profile
70μJ Spark Energy

Breakdown = 7000 V
Voltage Rise = 1.3e10 V/s

Ionization Spark Duration = 100 ns
Typical Energy Measurement

Energy = \int (\text{Voltage} \times \text{Current}) \, dt
Oscillating Sparks
Nice Looking Spark
Nice Looking Spark -- Animation
Reaction Wave
Carbon Build Up
Carbon Build Up --Animation
Methanol

Equivalence Ratio

Time to Peak Pressure (ms)

Pressure Rise (psi)
Effect of Vapor Composition on Minimum Ignition

- Methanol
- Methanol/Isopropanol
- Isopropanol
- Minimum Spark in Air
Methanol Minimum Ignition Energy
Effect of Electrical Isolation

Equivalence Ratio ($\Phi$)

log (MIE/mJ)

Series 1
Series 2
Series 3

Methanol Minimum Ignition Energy
Effect of Electrical Isolation

Teflon
No Teflon
Methanol MIE vs Spark Duration

![Graph showing the relationship between log (E_i / mJ) and log (τ/μs) for different temperatures.]

- 12.5 °C
- 14.5 °C
- 17.5 °C
- 20.0 °C
- 22.5 °C
- 25.0 °C
- 27.5 °C
- 32.5 °C
Methanol Minimum Ignition Energy
Effect of Varying Spark Duration

Equivalence Ratio ($\Phi$) vs. log (MIE/mJ)

- 10 µs
- 100 µs
- 1000 µs
- Actual Minima
Iso-Octane MIE @ 21°C
Effect of Varying Spark Duration

Spark Duration (µs)

Minimum Ignition Energy (mJ)
More Than Enough Energy
MIE Curves for Methanol and Iso-Octane

Equivalance Ratio

Minimum Ignition Energy

- Iso-Octane
- Methanol
- All Spark Durations
Conclusions

MIE Depends Upon Ignition Source and Duration

Shape of MIE vs Temperature Curves Varies Strongly with Spark Properties

Not So Easy – Need To Find Spark Duration for MIE at Each Condition